UNIVERSITY OF ALBERTA LIBRARY
0 1620 0282 5295

LB
3054
C2
D52575
1994/1995
c.3

EDUC

EX LIBRIS
UNIVERSITATIS
ALBERTÆNSIS

1994-95 School Year

Physics 30 Information Bulletin

Diploma Examinations Program

Students First!
Student Evaluation

Alberta
EDUCATION

This document was written primarily for:

Students	✓
Teachers	✓ Physics 30 teachers
Administrators	✓
Parents	
General Audience	
Others	

Distribution: Superintendents of Schools • School Principals and Teachers • The Alberta Teachers' Association • Alberta Education • General Public upon Request

Copyright 1994, the Crown in Right of Alberta, as represented by the Minister of Education, Alberta Education, Student Evaluation Branch, 11160 Jasper Avenue, Edmonton, Alberta, T5K 0L2. All rights reserved. Additional copies may be obtained from the Student Evaluation Branch, 403-427-0010.

Permission is granted to Alberta educators to reproduce, for educational purposes and on a non-profit basis, this bulletin or any of its parts.

UNIVERSITY LIBRARY
UNIVERSITY OF ALBERTA

Contents

Page

1 PURPOSE OF THE BULLETIN

GENERAL INFORMATION

2 1995 Grade 12 Diploma Examinations Schedule
2 1995 Marking Information
2 1994–95 Field Testing and Item Writing
NEW 3 Format of the Sciences Examinations
NEW 3 Assessment of Skills and STS Connections
NEW 4 Standards
4 Use of Scientific Calculators on Examinations
NEW 4 Rescores
4 Examiners' Reports
4 School and Jurisdiction Statistical Reports
4 Annual Report

NEW **PHYSICS 30 INFORMATION**

5 Standards
6 Examination Specifications
7 Examination Design

NEW **SAMPLE TEST ITEMS, SCORING CRITERIA, AND SAMPLE ANSWERS**

8 Sample Test
24 Scoring Criteria
26 Sample Answers

APPENDICES

REVISED 31 *Appendix A* Policy: Use of Scientific Calculators on Alberta Education Diploma Examinations
REVISED 32 *Appendix B* Examination Rules, Grade 12 Diploma Examinations
33 *Appendix C* Guidelines for Significant Digits, Manipulation of Data, and Rounding in the Mathematics and Sciences Diploma Examinations
34 *Appendix D* Explanations of Cognitive Levels Directing Words
36 *Appendix E* Preparing to Write a Science Diploma Examination—What every student should do before the examinations!
37 *Appendix F* Suggestions for Students When Writing Science Diploma Examinations—What every student should know when writing examinations!

Digitized by the Internet Archive
in 2016

https://archive.org/details/diplomaexaminat1994albe_3

Purpose of the Bulletin

The purpose of science bulletins is to provide students and teachers of the sciences with information about the diploma examinations scheduled for 1995. Science bulletins include descriptions of the examinations in the sciences that will be administered in January, June, and August of 1995; they outline the objectives to be tested and provide information about the design of the examinations. They provide guidelines for completing the machine-scored answer sheets, use of calculators, and the manipulation of data. Definitions of directing words, which are used to convey expectations for students' responses to exam questions, are given in the appendices along with suggestions for students when preparing for writing diploma examinations.

The bulletins describe the acceptable standard and the standard of excellence for Biology 30, Chemistry 30, Physics 30, and Science 30. These descriptions will give readers a general impression of the levels of achievement expected of students in each of the 30-level science courses.

The revised courses in Biology 30, Chemistry 30, and Physics 30 are being implemented this school year (1994–95). The revisions in these courses have implications for the design of the corresponding diploma examinations. Specific information concerning achievement expectations, sample questions, scoring criteria, and sample answers are provided in the bulletin for each of these courses.

The new Science 30 course is also being implemented this school year. All schools that offer the Science 30 course will be provided with year-end pilot tests. These tests will be prototypes of the Science 30 diploma examinations that will be administered starting the following school year (1995–96). Specific information concerning achievement expectations, sample questions, scoring criteria, and sample answers are provided in the bulletin for Science 30.

The Science 30 year-end pilot tests will be written according to the 1995 Diploma Examination Schedule, scored in the schools, and then returned to Alberta Education. The students' final course marks will be awarded by the school and will incorporate a 25% minimum weighting of the pilot test score. Students' marks on year-end pilot tests will not be reported separately to Information Services.

Inservices and Presentations

On a limited basis and subject to budget constraints, Student Evaluation Branch staff is available to provide inservices or presentations related to diploma examinations or the interpretation of diploma examination results.

If you have requests, questions, or comments about the contents of this bulletin, please contact:

Lowell Hackman, Coordinator
Mathematics/Sciences Unit

David Bridgewater
Examination Manager, Biology 30

John Drader
Examination Manager, Science 30

Greg Hall
Examination Manager, Physics 30

Don Loerke
Examination Manager, Chemistry 30

Mailing address, telephone, and fax number:

Student Evaluation Branch
Alberta Education
Devonian Building, West Tower
11160 Jasper Avenue
Edmonton, Alberta T5K 0L2

Phone: 403-427-0010
FAX: 403-422-4200

General Information

1995 Grade 12 Diploma ExaminationsSchedule

Date	*Time**	*Examination*
Thurs., Jan. 26	9:00–11:30 A.M.	Biology 30
	1:00–3:30 P.M.	Physics 30
Fri., Jan. 27	9:00–11:30 A.M.	Chemistry 30
	1:00–3:30 P.M.	Science 30 Pilot
Tues., June 27	9:00–11:30 A.M.	Biology 30
	1:00–3:30 P.M.	Physics 30
Wed., June 28	9:00–11:30 A.M.	Chemistry 30
	1:00–3:30 P.M.	Science 30 Pilot
Tues., Aug. 15	1:00–3:30 P.M.	Chemistry 30
Wed., Aug. 16	1:00–3:30 P.M.	Science 30 Pilot
Thurs., Aug. 17	9:00–11:30 A.M.	Biology 30
	1:00–3:30 P.M.	Physics 30

*The diploma examinations are designed for a writing time of 2.5 hours. Students will have an additional 0.5 h to complete the examinations.

There are no changes to the examination requirements. It is expected that 2.5 hours is adequate for each examination; however, the extra 0.5 hour is available for those students who need it.

1995 Marking Information

The written-response questions of the diploma examinations in the sciences are marked by classroom teachers. These markers are selected from teachers who have been recommended by their superintendents. To qualify for recommendation in all subjects except Science 30, a teacher must have taught the subject for two or more years, be currently teaching the subject, and have an Alberta Permanent Professional Certificate.

For Science 30, a teacher must have taught the subject previously or be currently teaching the subject, and have a valid Alberta Permanent Professional Certificate.

The following criteria are considered when markers are selected for a particular marking session:

- experience as a marker (generally, first-time markers are given priority)
- regional representation (by zone, jurisdiction, and school)
- student population (proportional representatio
- gender balance

We particularly need teachers who can mark examinations written in French.

Teachers who wish to be recommended as marke for the January 1995 examinations should contac their superintendents before October 1, 1994. Teachers who wish to be recommended as marke for the June and August 1995 examinations shou contact their superintendents before March 1, 199

Tentative dates for marking of the 1995 science diploma examinations are:

January Administration	February 7 to 11
June Administration	July 10 to 14
August Administration	August 18 to 19

1994–95 Field Testing and Item Writing

As the need arises for teachers to participate in field testing and item writing, letters are sent to superintendents requesting their nominations. Teachers who are interested in these activities should let their superintendents know early in the school term.

Format of the Sciences Examinations

All examinations in the four sciences have both machine-scored questions and teacher-scored (written-response) questions.

The machine-scored questions are of two types: multiple-choice and numerical-response. Please refer to the *Physics 30 Information* section of this bulletin for further details about numerical-response questions.

Each examination in the sciences has two written-response questions. At least one of these will be an open-response question. Students' answers to open-response questions are scored by teachers using holistic scoring guides. These guides describe the characteristics of students' answers that correspond to one of five values: 0, 1, 2, 3, or 4. Each student's answer is scored independently by two teachers. The two sub-scores are added together for a combined total raw score.

The other written-response question on each examination may be a closed-response question. Students' answers to closed-response questions are scored by teachers using analytical scoring keys. Each student's answer is scored by only one teacher.

Examination questions are organized into related sets. A set may be introduced by a general scenario that serves as an organizer for one or more contexts. This introductory statement will be screened.

A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

If required, a screened bar will indicate the end of a set.

A separate data booklet is provided for the Chemistry 30 and Science 30 (Pilot) examinations. The Biology 30 and Physics 30 examinations contain tear-out data pages. All examinations in the four sciences have tear-out pages for rough work.

Assessment of Skills and STS Connections

Students' understanding of the concepts of science are measured by every question on the examinations. In addition, some questions measure the students' development of the skills and thinking processes associated with scientific inquiry. Some questions will measure students' understanding of the interrelationships between science and technology and among science, technology, and society.

Communication skills are assessed most directly in the teacher-scored questions. For some closed-response questions, in addition to the analytical scoring key, a separate holistic scoring guide may be used. For the open-response questions, the descriptions used in the holistic scoring guides may include criteria for assessing communication skills along with criteria for the other components. Examples of scoring criteria can be found on page 25.

The term *communication skills* includes those processes by which information is exchanged through appropriate conventions. These conventions include:

- words, sentences, paragraphs
- graphs, diagrams
- mathematical formulas, mathematical and chemical equations
- significant digits, units of measurement

Conventions that are considered appropriate for a particular response are subject- and question-specific.

Standards

Standards in education are statements that communicate the level of performance necessary to attain a specific goal or objective. Standards assist educators in determining the extent to which students must know content and demonstrate required skills to pass the course.

Standards of student achievement are described in general at the beginning of the *Physics 30 Information* section. These standards are applicable to students who attain the *acceptable* standard (a final mark of 50% or higher) and to students who attain the standard of *excellence* (a final mark of 80% or higher).

A more detailed description of specific learner expectations (standards) accompanied by sample questions, answers, scoring criteria, and samples of student responses is given in the *Sample Test Items, Scoring Criteria, and Sample Answers* section.

Use of Scientific Calculators on Examinations

Examinations are constructed to ensure that the use of particular scientific calculators neither advantages nor disadvantages individual students.

Please refer to Appendix A for the policy statement on the use of scientific calculators on diploma examinations. Students should be made aware of this policy as early as possible in the school term to ensure they are able to use the scientific calculator of their choice when writing examinations.

Students should also be made aware of the Examination Rules, Grade 12 Diploma Examinations (see Appendix B). Students should know that notes stored in electronic devices may not be brought into the examination room.

Rescores

A student may request a rescoring of the diploma examination if he or she believes that the mark received is not appropriate. However, before applying for a rescoring, it is important to check the distribution of marks in the examination. The machine-scored mark is not likely to change as a result of a rescore, but the written-response mark could change slightly. Students should remember that the rescored mark will be the final mark whether it *increases* or *decreases*.

Examiners' Reports

Following the administration of the January and June examinations, examiners' reports are released. These reports briefly outline the statistical data obtained from the examination administration and provide a diagnostic overview of student performance. Examiners' reports are designed for teacher use. If we can make these reports more useful to you, please let us know.

School and Jurisdiction Statistical Reports

Superintendents and principals receive detailed statistical reports on how well the students in thei school district did on the sciences examinations. Teachers use these data to reflect on the areas of the program where their students did well and those areas where student performance was poor.

Annual Report

A document entitled *Annual Report, Diploma Examination Program,* that summarizes results from the January, June, and August diploma examination administrations is published each year. The purpose of this report is to inform educators and the public about student achievement in relation to provincial standards.

Physics 30 Information

Standards

Students who attain an *acceptable* standard in Physics 30 have gained new skills and knowledge in physics but may encounter difficulties if they choose to enroll in post-secondary physics courses. These students can state and solve problems that can be related quickly to an equation on the data sheets. Their laboratory skills are limited to following explicit directions and to using laboratory data to verify known physics information. These students are capable of defining and calculating quantities such as one dimensional momentum; kinetic and potential energies; electric force and the force due to gravity; current, potential difference, and resistance in simple series and parallel circuits; variables in the relationship between the primary and secondary coils of a transformer; speed, wavelength, and frequency of electromagnetic waves; charge-to-mass ratios; and the photoelectric work function. They tend o use item-specific methods in their problem solving and rarely apply the major generalizations of physics such as conservation aws of charge, momentum, and energy. When explaining the connections between science, echnology, and society, these students tend to use examples provided from textbooks and have difficulty connecting physics to real-life scenarios beyond the classroom.

Students who attain a standard of *excellence* in Physics 30 have demonstrated their ability and interest in both mathematics and physics and feel confident about their scientific abilities. These students should encounter little difficulty in post-secondary physics programs and should be encouraged to pursue careers in which they will utilize their talents in physics. Students who attain a standard of *excellence* show flexibility and creativity when solving problems, and minor changes in problem format do not cause these students major difficulties. They seek general methods to solve problems and are not afraid to use conservation laws. They transfer knowledge from one area of physics to another and can express their answers in clear and concise terms. In addition, these students can connect their understanding of physics to real world situations that include technological applications and implications beyond the classroom setting. In the laboratory, students who attain a standard of *excellence* can cope with data that are less than perfect or with instructions that are incomplete. These students are capable of defining and calculating quantities such as two-dimensional momentum; current and voltage using Kirchoff's rules; resistance in series and parallel circuits; the motion of an electric charge in a magnetic field; and variables in the Balmer equation.

Examination Specifications

Each Physics 30 Diploma Examination is constructed as closely as possible to the following specifications. Adjustments in the emphasis may be necessary because the exam includes written-response questions and/or machine-scored questions that cover more than one general learner expectation. Questions on the diploma examination will require students to demonstrate knowledge of physics concepts and apply skills in a context that supports making STS connections.

Knowledge	***Emphasis***
The student can:	
• compare and contrast scalar and vector quantities and fields; apply the concept of field to quantitatively explain, in terms of their source, direction and intensity, the gravitational, electrical and magnetic effects on objects and systems	10–20%
• describe, quantitatively analyze, and predict the behaviour and physical interactions of objects that may be in gravitational, electric, and/or magnetic fields, using the principles of kinematics, dynamics, conservation of energy, momentum, and electric charge, in addition to electrostatics and electromagnetism; apply these principles to atomic theory and other applications	35–45%
• explain, quantitatively analyze, and predict the functioning of simple resistive direct current circuits using Ohm's law and Kirchoff's rules; the motor/generator effect; explain the design, function, and technological applications of simple electric motors, generators, meters, transformers, and other simple electromagnetic devices	10–20%
• explain, quantitatively the characteristics and behaviours of electromagnetic waves and algebraically solve problems using the relationship among speed, wavelength, frequency, and energy, and apply these principles with conservation laws to the atomic theory and other applications	25–35%

Skills	***Emphasis***
The student can:	20–40%

- design, interpret, explain, analyze, and evaluate investigations
- organize data into tables, graphs, and diagrams and predict relationships
- interpret, explain, analyze, and evaluate data to infer relationships
- use appropriate scientific terminology and mathematical language to communicate and explain scientific concepts

Connections Among Science, Technology, and Society (STS)	***Emphasis***
The student can:	40–60%

- apply cause-and-effect reasoning to formulate relationships in which scientific evidence shapes or refutes a theory, and explain the limitations of science and technology in answering all questions and solving all problems
- describe and evaluate the design and function of technological solutions to theoretical and practical problems, and relate the ways in which science and technology advance one another
- evaluate from a variety of perspectives how science and technology are influenced and supported by society, and assess the ability to interact responsibly with the environment
- apply the skills and knowledge acquired in science to everyday life

Examination Design

The design of the 1995 Physics 30 diploma examinations is as follows:

Question Format	*Number of Questions*	*Percent Emphasis*
Multiple Choice	37	53
Numerical Response	12	17
Written Response	2	30

The design supports the integration of all Physics 30 general learner expectations as outlined in the *Physics 20-30 Program of Studies, Interim, for Senior High Schools*. As a result, the exam is not necessarily arranged sequentially by units but instead is built around scenarios or contexts that support STS connections.

A change to the Physics 30 Diploma Examinations is the scoring of certain multiple-choice and numerical-response questions. In the past, all multiple-choice and numerical-response questions were developed and scored independent of one another. Now, with the development of more than one question based on the same block of information, a numerical answer from one question may be necessary to complete the calculations in the next question. If students answer the first question incorrectly but use that answer correctly to answer the second question, they will receive full marks for the second question.

To illustrate by example numerical-response questions 3 and 4 in the sample examination are of this type. In NR question 3, the student is required to generate a numerical response for the energy lost by a photon and express it in scientific notation to three digits. Numerical-response question 4 requires the student to then use the answer from NR question 3 to calculate the answer. If the student answers NR question 3 incorrectly but then uses that value to correctly answer NR question 4, the student's response will be marked correct. These variations in answers can be accommodated by the programming designed for electronic scoring.

Sample Test Items, Scoring Criteria, and Sample Answers

Sample Test

The following sample examination reflects the design format and examination specifications as closely as possible. As a result, it also reflects the format and question types that will appear in the 1995 Physics 30 Diploma Examination.

The exam is in a ready-to-use format with tear-out data sheets (pages 20-23) and an answer sheet (page 24) located at the end of the test. Some of the test items included in this exam have been field tested. All questions have been developed by teachers from across the province

Exam summary sheets, scoring guides, and samples of student work for the written respons question follow the exam. To arrive at a student's response out of four, use the holistic scoring guide provided and multiply by two for a maximum of eight marks. Criteria for physics content and communication skills are included in the holistic scoring guide for this sample examination.

Physics 30

Year-End Examination

Description

Time: 60 minutes
Total possible marks: 25

This is a **closed-book** test consisting of
13 multiple-choice questions and
4 numerical-response questions
each with a value of one mark, and
1 written-response question with a value
of 8 marks, for a total of 25 marks.

Physics tear-out data sheets are provided at the end of the test.

Instructions

- Fill in the information required on the answer sheet and the test.
- You are expected to provide your own scientific calculator.
- Carefully read the instructions before proceeding.

Multiple Choice

- Use an HB pencil only for machine-scored answer sheet.
- If you wish to change an answer, erase all traces of your first answer.
- Read each question carefully. Consider all numbers used in the questions to be exact real numbers and not the result of a measurement.
- Decide which of the choices **best** completes the statement or answers thequestion.
- Locate that question number on the separate answer sheet provided and fillin the circle that corresponds to your choice.

Example

This diploma examination is for the subject of

A. biology
B. physics
C. chemistry
D. mathematics

Answer Sheet
Ⓐ ● Ⓒ Ⓓ

Numerical Response

- Use an HB pencil only for machine-scored answer sheet.
- If you wish to change an answer, erase all traces of your first answer.
- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

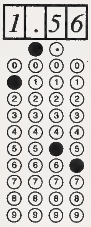
Example 1

If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass would be ________ m/s^2.
(Round and record your answer to three digits.)

$$a = \frac{F}{m}$$

$$a = \frac{121\text{N}}{77.7\text{kg}} = 1.5572716$$

Record 1.56 on the answer sheet ⟶



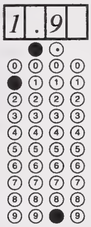
Example 2

A microwave of wavelength 16 cm has a frequency of $\boldsymbol{b} \times 10^9$ Hz. The value of $\boldsymbol{b}$ is __________.

(Round and record your answer to two digits.)

$$f = c/\lambda$$
$$= (3.00 \times 10^8 \text{ m/s})/(0.16 \text{ m})$$
$$f = 1.875 \times 10^9 \text{ Hz}$$

Record 1.9 on the answer sheet ⟶



Written Response

- Consider all numbers used in the question to be the result of a measurement.
- Read the question carefully.
- Write your answer in the test booklet as neatly as possible.
- For full marks, your answers **must show all** pertinent explanations, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences for a written response, and correct units and significant digits for a numerical response.

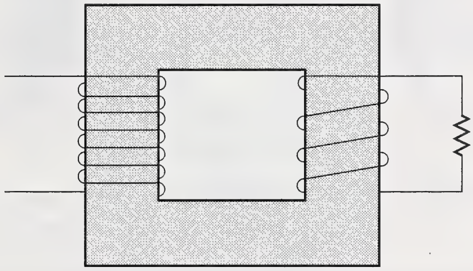
Do not turn the page to start the test until told to do so by the presiding examiner.

1. During a tennis game, the ball was measured to have a speed of 153 km/h at a height of 1.75 m at a specific point. If the average mass of a tennis ball is 5.70×10^{-2} kg, the **total** mechanical energy of the ball at that point is

A. 669 J
B. 104 J
C. 52.5 J
D. 51.5 J

Use the following information to answer the next two questions.

Step-Down Transformer



2. Transformers are used to provide low alternating current for the transmission of telephone conversations. A method used to listen in on telephone conversations, is to lay a wire, connected to headphones, beside a telephone wire. This method of wire-tapping works because it produces

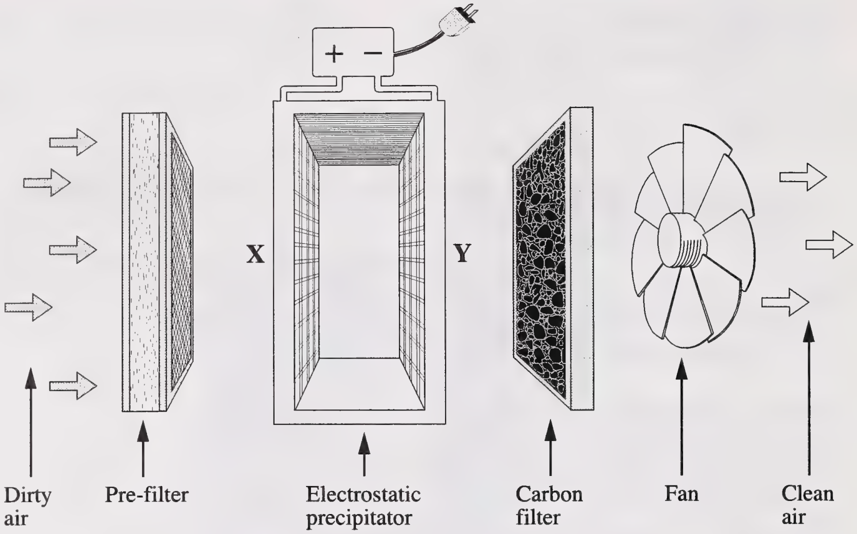
A. alternating electric and magnetic fields
B. an induced electric field in the headphone wire
C. an induced current in the headphone wire
D. the transfer of EMR between wires

Numerical Response

1. A step-down transformer, 3600 V/120 V is used to decrease the voltage of a powerline so that it can be used by a resistance applicance (eg., toaster) connected to the secondary winding. The current in the primary winding is 0.608 A. The value of the resistance, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}\ \Omega$.
The value of ***b*** is ____________ .
(Round and record your answer to three digits.)

Use the following information to answer the next two questions.

Air Cleaner



$$|\vec{E}| = 6.00 \times 10^4 \text{ N/C}$$

A popular type of air cleaner uses an electrostatic precipitator to remove very fine particles from the air. The precipitator works by giving a charge to particles in the air (side **X**) and then trapping them with a grid charged with the opposite charge (side **Y**).

3. As the dirty air passes through side **X**,

A. protons are removed from the particles giving them a net negative charge
B. electrons are added to the particles giving them a net negative charge
C. electrons are removed from the particles giving them a net positive charge
D. protons are added to the particles giving them a net positive charge

4. A particle with a mass of 2.30×10^{-19} kg and a charge of 2.40×10^{-18} C enters the space inside the electrostatic precipitator. The acceleration of the particle toward side **Y** due to electrostatic forces alone is

A. 6.26×10^{5} m/s^2
B. 4.17×10^{4} m/s^2
C. 1.6×10^{-6} m/s^2
D. 2.5×10^{-18} m/s^2

Use the following information to answer the next question.

The following statements are true regarding cosmic rays entering the Earth's atmosphere.

Cosmic rays: I penetrate solids
II discharge electroscopes
III are deflected by the Earth's magnetic field

5. The statements that do not support the notion that cosmic rays are charged particles are

A. I and II only
B. I and III only
C. II and III only
D. I, II, and III

Numerical Response

2. Alpha (α^{2+}) and beta (e^-) particles travelling at the same speed pass through the same magnetic field perpendicularly to their path. The ratio of the radius for the alpha particle with respect to the beta particle is $b \times 10^{w}$ to 1.
The value of ***b*** is ___________ .
(Round and record your answer to three digits.)

Use the following information to answer the next four questions.

A solar-powered battery-saver is intended to maintain batteries for automobiles, recreational vehicles, etc. It uses a solar cell with dimenstions of 35 cm × 12 cm. Under full sun intensity, the solar cell produces 100 mA of current at 14.5 V.

6. Connecting two battery-savers in parallel would

A. increase the current but the voltage would remain approximately the same
B. increase the voltage but the current would remain approximately the same
C. increase both the voltage and the current
D. increase neither the voltage nor the current

7. If a red filter were placed over the battery-saver, the result would most likely be

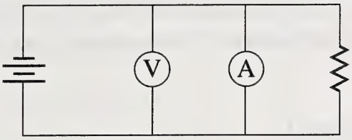
A. a decrease in current because of the decreased average frequency of the light
B. a decrease in voltage because of the decreased average frequency of the light
C. an increase in voltage because of the increased average wavelength of the light
D. an increase in current because of the increased average wavelength of the light

8. The amount of electrical energy produced in 1.00 h under full sun intensity by each 1.00 cm^2 of the solar cell would be

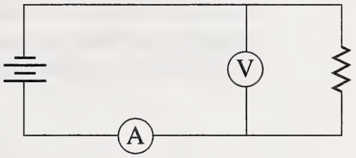
A. 3.45×10^{-3} J/cm^2
B. 5.22×10^{3} J/cm^2
C. 1.24×10^{1} J/cm^2
D. 1.24×10^{2} J/cm^2

9. To measure the electrical work supplied to a heater by a battery, requires measurements from ammeter A and voltmeter V. Which of the circuits below should be used?

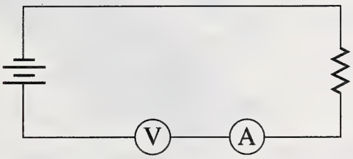
A.



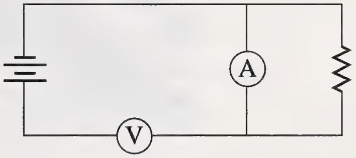
B.



C.



D.



Use the following information to answer the next two questions.

Photons created at the centre of the sun ricochet within the sun randomly for up to 150 000 y. Therefore, an originally high energy X-ray photon ($\lambda = 7.00 \times 10^{-12}$ m) reaches the surface mainly as yellow light ($\lambda = 5.00 \times 10^{-7}$ m).

Numerical Response

3. The energy this photon has lost in its journey, expressed in scientific notation, is $b \times 10^{-w}$ J. The value of b is ____________ .
(Round and record your answer to three digits.)

4. Using your answer from **Numerical Response 3**, the energy lost by the photon, expressed in scientific notation, is $b \times 10^{w}$ eV. The value of b is ____________ .
(Round and record your answer to three digits.)

Use the following information to answer the next two questions.

Railway companies are interested in preventing accidents by detecting hot boxes. A hot box occurs when a wheel bearing fails, and it results in heat and possible fire or derailment. To detect the presence of a wheel, a device called a transducer is used. The transducer contains a free-moving magnet and a coil of wire as shown below.

Diagram I

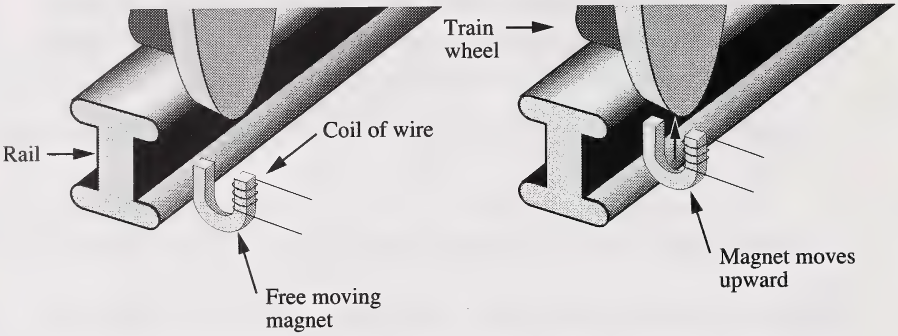
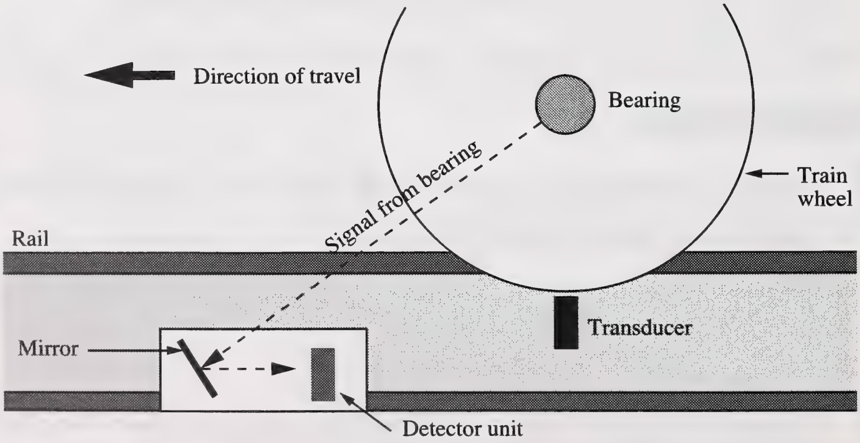


Diagram II

The device below is used to detect the hot bearing.



10. The effective length of the coil wire is 250 m. The magnet of strength 5.00×10^{-5} T moves upward with velocity of 3.00 m/s. The voltage induced in the coil is

A. 3.75×10^{8} V

B. 1.50×10^{7} V

C. 3.75×10^{-2} V

D. 4.17×10^{-3} V

11. The signal generated from a hot bearing could be described as

A. an electric field only
B. a magnetic field only
C. parallel magnetic and electric fields
D. perpendicular magnetic and electric fields

12. To detect the presence of a hot bearing, the detector unit is designed to recognize

A. infrared waves
B. visible light waves
C. ultraviolet waves
D. radio waves

---

13. A typical nuclear reaction taking place within the sun to produce huge quantities of energy is represented by

A. ${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{144}_{56}\text{Ba} + {}^{90}_{36}\text{Kr} + 2{}^{1}_{0}\text{n} + \text{energy}$

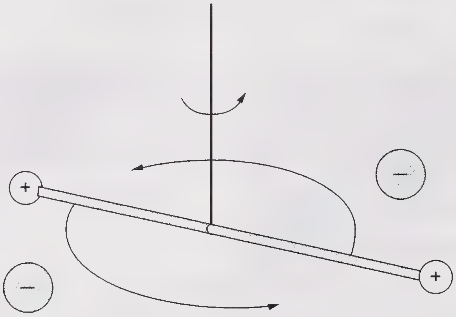
B. $\text{H}_2 + \frac{1}{2}\text{0}_2 \rightarrow \text{H}_2\text{O} + \text{energy}$

C. ${}^{2}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{2}\text{H} + {}^{1}_{0}\text{n} + \text{energy}$

D. $\text{H} + \text{H} \rightarrow \text{H}_2 + \text{energy}$

Use the following information to answer the next question.

Both Charles Coulomb and Henry Cavendish used a torsion balance to study electrical and gravitational forces, respectively. Coulomb measured the electrical forces of attraction (or repulsion) between charged spheres; Cavendish studied the gravitational attraction of neutral spheres.



The small swinging masses are 1.0 kg and the larger stationary masses are 15.0 kg. The magnitude of each charge is 2.6×10^{-8} C.

(8 marks)

1. Using a sample calculation, **compare** the electrical and gravitational forces and **explain why** Coulomb's measurements of electrical forces were **not** significantly affected by the attraction of the sphere's masses due to gravity.

PHYSICS DATA SHEETS

CONSTANTS

Gravity, Electricity, And Magnetism

Acceleration Due to Gravity **or** Gravitational Field Near Earth	a_g or $g = 9.81\ \text{m/s}^2$ or $9.81\ \text{N/kg}$
Gravitational Constant	$G = 6.67 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$
Mass of Earth	$M_e = 5.98 \times 10^{24}\ \text{kg}$
Radius of Earth	$R_e = 6.37 \times 10^{6}\ \text{m}$
Coulomb's Law Constant	$k = 8.99 \times 10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2$
Electron Volt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$
Elementary Charge	$e = 1.60 \times 10^{-19}\ \text{C}$
Index of Refraction of Air	$n = 1.00$
Speed of Light in Vacuum	$c = 3.00 \times 10^{8}\ \text{m/s}$

Atomic Physics

Energy of an Electron in the 1st Bohr Orbit of Hydrogen	$E_1 = -2.18 \times 10^{-18}\ \text{J}$ or $-13.6\ \text{eV}$
Planck's Constant	$h = 6.63 \times 10^{-34}\ \text{J}\cdot\text{s}$
Radius of 1st Bohr Orbit of Hydrogen	$r_1 = 5.29 \times 10^{-11}\ \text{m}$
Rydberg's Constant for Hydrogen	$R_H = 1.10 \times 10^{7}/\text{m}$

Particles

	Rest Mass	**Charge**
Alpha Particle	$m_\alpha = 6.65 \times 10^{-27}\ \text{kg}$	α^{2+}
Electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	e^-
Neutron	$m_n = 1.67 \times 10^{-27}\ \text{kg}$	n^0
Proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	p^+

Trigonometry And Vectors

$$\sin\theta = \frac{opposite}{hypotenuse} \quad \text{or} \quad \sin\theta = \frac{y}{r}$$

$$\cos\theta = \frac{adjacent}{hypotenuse} \quad \text{or} \quad \cos\theta = \frac{x}{r}$$

$$\tan\theta = \frac{opposite}{adjacent} \quad \text{or} \quad \tan\theta = \frac{y}{x}$$

For any Vector $\vec{R}$

$$R = \sqrt{R_x{}^2 + R_y{}^2}$$

$$R_x = R\cos\theta$$

$$R_y = R\sin\theta$$

$$\tan\theta = \frac{R_y}{R_x}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

Prefixes Used With SI Units

Prefix	Symbol	Exponential Value	Prefix	Symbol	Exponential Value
pico	p	10^{-12}	tera	T	10^{12}
nano	n	10^{-9}	giga	G	10^{9}
micro	µ	10^{-6}	mega	M	10^{6}
milli	m	10^{-3}	kilo	k	10^{3}
centi	c	10^{-2}	hecto	h	10^{2}
deci	d	10^{-1}	deka	da	10^{1}

EQUATIONS

Kinematics

$$\vec{v}_{\text{ave}} = \frac{\vec{d}}{t}$$

$$\vec{a} = \frac{\vec{v}_{\text{f}} - \vec{v}_{\text{i}}}{t}$$

$$\vec{d} = \vec{v}_{\text{i}}t + \frac{1}{2}\vec{a}t^2$$

$$\vec{d} = \vec{v}_{\text{f}}t - \frac{1}{2}\vec{a}t^2$$

$$\vec{d} = \left(\frac{\vec{v}_{\text{f}} + \vec{v}_{\text{i}}}{2}\right)t$$

$$v_{\text{f}}^2 = v_{\text{i}}^2 + 2ad$$

Dynamics

$$\vec{F} = m\vec{a}$$

$$\vec{F}t = m\Delta\vec{v}$$

$$\vec{F}_{\text{g}} = m\vec{g}$$

$$F_{\text{f}} = \mu F_{\text{N}}$$

$$\vec{F}_{\text{s}} = -k\vec{x}$$

$$F_{\text{g}} = \frac{Gm_1m_2}{r^2}$$

$$g = \frac{Gm_1}{r^2}$$

$$F_{\text{c}} = \frac{mv^2}{r}$$

$$F_{\text{c}} = \frac{4\pi^2mr}{T^2}$$

Momentum and Energy

$$\vec{p} = m\vec{v}$$

$$W = Fd$$

$$W = \Delta E = Fd\cos\theta$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

$$E_{\text{k}} = \frac{1}{2}mv^2$$

$$E_{\text{p}} = mgh$$

$$E_{\text{p}} = \frac{1}{2}kx^2$$

Waves and Light

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T = \frac{1}{f}$$

$$v = f\lambda$$

$$\frac{\lambda_1}{2} = l; \ \frac{\lambda_1}{4} = l$$

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$\lambda = \frac{xd}{nl}$$

$$\lambda = \frac{d\sin\theta}{n}$$

$$m = \frac{h_{\text{i}}}{h_0} = \frac{-d_{\text{i}}}{d_0}$$

$$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_{\text{i}}}$$

EQUATIONS

Electricity and Magnetism

$$F_e = \frac{kq_1q_2}{r^2}$$

$$V = IR$$

$$|\vec{E}| = \frac{kq_1}{r^2}$$

$$P = IV$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$

$$I = \frac{q}{t}$$

$$|\vec{E}| = \frac{V}{d}$$

$$F_m = IlB_\perp$$

$$V = \frac{\Delta E}{q}$$

$$F_m = qvB_\perp$$

$$R = R_1 + R_2 + R_3$$

$$V = lvB_\perp$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$$I_{eff} = 0.707\, I_{max}$$

$$V_{eff} = 0.707\, V_{max}$$

Atomic Physics

$$hf = E_{k_{max}} + W$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$W = hf_0$$

$$E_n = \frac{1}{n^2}E_1$$

$$E_{k_{max}} = qV_{stop}$$

$$r_n = n^2 r_1$$

$$E = hf = \frac{hc}{\lambda}$$

$$N = N_0\left(\frac{1}{2}\right)^n$$

Quantum Mechanics and Nuclear Physics

$$E = mc^2$$

$$p = \frac{h}{\lambda}$$

$$p = \frac{hf}{c}; \ E = pc$$

Physics 30 Year-end Examination Answer Sheet

Student's Name______________________________ Class______________________

Multiple Choice

	A	B	C	D
1	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13	Ⓐ	Ⓑ	Ⓒ	Ⓓ

Numerical Response

1	2	3	4
☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
⊙ ⊙	⊙ ⊙	⊙ ⊙	⊙ ⊙
⓪ ⓪ ⓪ ⓪	⓪ ⓪ ⓪ ⓪	⓪ ⓪ ⓪ ⓪	⓪ ⓪ ⓪ ⓪
① ① ① ①	① ① ① ①	① ① ① ①	① ① ① ①
② ② ② ②	② ② ② ②	② ② ② ②	② ② ② ②
③ ③ ③ ③	③ ③ ③ ③	③ ③ ③ ③	③ ③ ③ ③
④ ④ ④ ④	④ ④ ④ ④	④ ④ ④ ④	④ ④ ④ ④
⑤ ⑤ ⑤ ⑤	⑤ ⑤ ⑤ ⑤	⑤ ⑤ ⑤ ⑤	⑤ ⑤ ⑤ ⑤
⑥ ⑥ ⑥ ⑥	⑥ ⑥ ⑥ ⑥	⑥ ⑥ ⑥ ⑥	⑥ ⑥ ⑥ ⑥
⑦ ⑦ ⑦ ⑦	⑦ ⑦ ⑦ ⑦	⑦ ⑦ ⑦ ⑦	⑦ ⑦ ⑦ ⑦
⑧ ⑧ ⑧ ⑧	⑧ ⑧ ⑧ ⑧	⑧ ⑧ ⑧ ⑧	⑧ ⑧ ⑧ ⑧
⑨ ⑨ ⑨ ⑨	⑨ ⑨ ⑨ ⑨	⑨ ⑨ ⑨ ⑨	⑨ ⑨ ⑨ ⑨

Scoring Criteria

The examination summary sheet that follows indicates, for each question, the keyed answer; estimated difficulty; corresponding concept, knowledge, skill, and/or STS connection; cognitive level; and assessment standard. The estimated difficulty of the question reflects the percent of students that teachers estimate will answer the question correctly. The numerical reference to concepts corresponds to the unit and major concept outlined in the Physics 30 Course of Studies. For example, multiple-choice question 3 is coded 30.2.1. This refers to Physics 30, Unit 2, Major Concept 1. The numerical coding of the knowledge, skill, and STS component for each question corresponds to the order that each description appears in the Course of Studies for the specific unit and major concept. The cognitive levels correspond to the descriptions listed in *Explanations of Cognitive Levels* (see Appendix D).

The last column on the summary sheet shows which questions should be answered correctly by those students attaining either the acceptable standard (A) or the standard of excellence (E).

Physics 30 Sample Examination Summary Sheet

Machine Scored

Item	Key	Diff.	Concept	Knowl.	Skill	STS	Cog. Level	Assessment Standard
MC1	C	0.70E*	30.1.1	3			C/A	A
MC2	C	0.60E	30.3.2	4	1	1	C/A	E
NR 1	6.67	0.70E	30.3.2	8			C/A	A
MC3	C	0.80E	30.2.1	1			C/A	A
MC4	A	0.70E	30.2.3	5			C/A	A
MC5	A	0.50E	30.3.2	4	1		HMA	E
NR 2	3.65	0.70E	30.4.3	2			HMA	E
MC6	A	0.70E	30.2.4	7		3	C/A	A
MC7	B	0.70E	30.4.2	6	2	1	C/A	A
MC8	C	0.50E	30.4.2	7	2	1	C/A	E
MC9	B	0.60E	30.2.4	6	3		K	A
MC10	C	0.924	30.3.2	7	1, 2	2	C/A	A
MC11	D	0.673	30.3.3	1, 6, 7	2	1	C/A	A
MC12	A	0.532	30.3.3	3, 5	2	3	C/A	A
NR 3	2.84	0.70E	30.4.2	2			C/A	A
NR 4	1.78	0.85E	30.4.1	5			C/A	A
MC13	C	0.80E	30.4.3	7			C/A	E

Written Response

Item	Value	Diff.	Concept	Knowl.	Skill	STS	Cog. Level	Assessment Standard
1	8	0.60E	30.2.2	4	2	2	HMA	A and E

Machine Scored	0.69E
Written Response Average	0.60E
Total Test Average	0.64E

*Estimated Difficulty

here are two written-esponse questions n each diploma examination. Combined they eflect 30% of the total examination mark. ne question will continue to be marked sing an analytic scoring guide. For this uestion, checks and/or marks are awarded for ach step of the solution. The second question will be open-ended and marked using a holistic scoring guide. The holistic scoring guide presented below is generic for the scoring of the written-response questions on science diploma exams. From these criteria, descriptions are further developed specific to the question asked.

Holistic Scoring Guide For Science Diploma Examinations

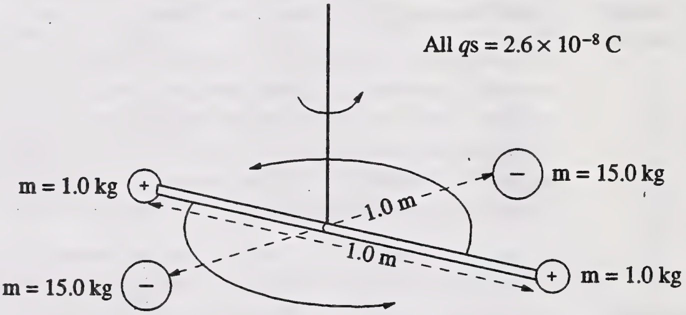
Score	Criteria
4 **Standard of Excellence**	The response is well organized and addresses all major points of the question. Relevant scientific, technological, and/or societal concepts are identified and interrelationships are explicit. The descriptions and/or explanations are well organized and reflect thorough understanding and logical consistency of thought. The student makes effective use of scientific vocabulary. When appropriate, diagrams and/or sketches are used to illustrate descriptions and/or explanations. There are no major omissions or inconsistencies.
3	The response is organized and addresses most of the major points of the question. Relevant scientific, technological, and/or societal concepts are identified and interrelationships are evident. The descriptions and/or explanations are organized and reflect correct understanding and logical consistency of thought. The student makes correct use of scientific vocabulary. When appropriate, diagrams and/or sketches are used to illustrate descriptions and/or explanations. There is at most one major omission or inconsistency.
2 **Acceptable Standard**	The response addresses some of the major points of the question. Relevant scientific, technological, and/or societal concepts are identified but few interrelationships are identified. The descriptions and/or explanations of these concepts show some understanding. The presentation demonstrates some organization of thought. There is one major omission and/or some inconsistencies.
1	The response addresses some of the major points of the question. Concepts are identified but interrelationships are not evident. The student superficially describes the concepts but organizational skills and scientific vocabulary are minimal. There are major omissions or inconsistency.
0	The response does not address any of the major points of the question.
NR	No response given

Sample Answers

The written-response question in the sample exam was field tested in schools piloting the revised Physics 30 Course of Studies during the 1993–94 school year. The following sample answers are intended to help teachers and students become familiar with the holistic scoring criteria. In addition, the commentary describes why the response has been awarded a 4 (Standard of Excellence), 3, 2 (Acceptable Standard), or 1. The following four sample answers are all responses to the written-response question given on page 24.

Use the following information to answer question 1.

Both Charles Coulomb and Henry Cavendish used a torsion balance to study electrical and gravitational forces, respectively. Coulomb measured the electrical forces of attraction (or repulsion) between charged spheres; Cavendish studied the gravitational attraction of neutral spheres.



The small swinging masses are 1.0 kg and the larger stationary masses are 15.0 kg. The magnitude of each charge is 2.6×10^{-8} C.

1. Using a sample calculation, **compare** the electrical and gravitational forces and **explain why** Coulomb's measurements of electrical forces were **not** significantly affected by the attraction of the sphere's masses due to gravity.

Sample Answer One (Standard of Excellence, Score 4)

One would expect that the difference between the forces would be large simply because the numerical difference between the Gravitational Constant and Coulomb's Constant is great.

$$G = 6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$$

$$k = 8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2$$

However, let's complete some simple routine calculations involving the electrostatic and gravitational interaction between the spheres and then compare the forces.

The gravitational force between the 1.0 kg and 15.0 kg masses can be calculated. Calculations are based on the assumption that the spheres are 1.0 metres apart.

$$F_g = \frac{Gm_1m_2}{r^2} = \frac{6.67\times10^{-11}\left(\frac{\text{N}\bullet\text{m}^2}{\text{kg}^2}\right)(1.0\ \text{kg})\ (15.0\ \text{kg})}{(1.0\ \text{m}^2)}$$

$$F_g = 1.0\times10^{-9}\ \text{N}$$

The electrostatic force between the charges can also be calculated. Again, calculations are based on the assumption that the spheres are 1.0 metres apart.

$$F_{el} = \frac{kq_1q_2}{r^2} = \frac{8.99\times10^{9}\left(\frac{\text{N}\bullet\text{m}^2}{\text{C}^2}\right)(2.6\times10^{-8}\ \text{C})(2.6\times10^{-8}\ \text{C})}{(1.0\text{m})^2}$$

$$F_{el} = 6.1\times10^{-6}\ \text{N}$$

When comparing the electrostatic force to the gravitational force a ratio can be found.

$$\frac{F_{el}}{F_g} = \frac{6.1\times10^{-6}\ \text{N}}{1.0\times10^{-9}\ \text{N}} \quad \text{or} \quad \frac{6.1\times10^{3}}{1} \quad \text{or}\ 6100\ \text{to}\ 1$$

The force due to electrostatic attraction is approximately 6100 times larger than the attraction due to gravity. This enormous difference would explain why Coulomb's measurements were not significantly affected by gravitational forces between the plates.

The response is well organized and addresses all the major points of the question. The comparison of the two constants suggests that the question has been analyzed and the task is understood. In addition, the response presents an efficient and workable strategy whereby the forces are calculated and then compared based on the assumption that the spheres are 1.0 metres apart. The concluding statements relate the relevance of the comparison back to the STS content in the question by explaining why Coulomb's measurements were not affected by the gravitational forces between the spheres.

The communication is precise and clear. This includes stating formulas, appropriate substitution, correct use of units, and significant digits. The information presented on the diagram is perceptive while explanations are logical and reflect a thorough understanding through the effective use of scientific vocabulary.

Sample Answer Two (Score 3)

The response is organized and addresses most of the major points of the question. The strategy used is appropriate; however, the comparison between the gravitational and electrical forces is not done. The reader must also assume that the distance used in both calculations is the same. The strategy used is not clear; however, the setup of the calculations suggests a comparison of the two forces.

The communication of the response is mostly clear. However, it is not clear how the comparison between the two forces is made or how the answer was calculated without a value for *r*. The reader must fill in the gaps to complete the calculations and explanations. Significant digits are not handled correctly, no information appears on the diagram, and units do not appear in the substitution. Scientific vocabulary used is appropriate. The explanation is logical; however, it is brief and lacks detail.

$$F_g = \frac{Gm_1m_2}{r^2} \qquad F_e = \frac{kq_1q_2}{r^2}$$

$$F_g = \frac{G(1)(15)}{\mathrm{r}^2} \qquad F_e = \frac{8.99 \times 10^9(2.6 \times 10^{-8})(2.6 \times 10^{-8})}{r^2}$$

$$F_g = \frac{(6.67 \times 10^{-11})(15)}{r^2} \qquad F_e = \frac{6.07724 \times 10^{-6}}{r^2}$$

$$F_g = \frac{1.001 \times 10^{-9}}{r^2} = 1.001 \times 10^{-9}\ \mathrm{N} \qquad F_e = 6.077 \times 10^{-6}\ \mathrm{N}$$

No matter what the distance is, the gravitational force will become smaller and smaller if the distance becomes larger and larger. You can only feel the effects of a gravitational force if your mass is of a significant size (very large). The gravitational force has little effect on the masses. The electrical force is greater.

Sample Answer Three (Acceptable Standard, Score 2)

$$\begin{array}{ll} F_g = F_e & F_g = \dfrac{(6.67 \times 10^{-11})(15.0)(15.0)}{(1.0^2)} \\ \dfrac{Gm_1m_2}{R} & F_e = \dfrac{(8.99^9)(2.6^{-8})(2.6^{-8})}{1.0^2} \\ F_g = 1.5 \times 10^{-8}\ \text{N} & F_e = 6.08 \times 10^{-6}\ \text{N} \end{array}$$

Coulomb's results were not significantly affected by gravity because unlike Cavendish he used charged spheres. The charging of the spheres made the attraction of the repulsive properties much stronger, therefore, almost completely overriding the forces of gravitational attraction. As demonstrated in the calculations, the electrical force is clearly stronger than the gravitational force, and therefore would not be greatly affected by it.

The response is somewhat organized and addresses most of the major points of the question. It is not clear why the gravitational force has been equated to the electrical in both instances; this indicates that the task was not readily understood and correctly analyzed. The strategy used is not clear; however, calculations suggest that a comparison could be made but isn't, until the last sentence.

Although the response correctly states that the electrical force is stronger than the gravitational force, the supporting calculations are flawed. The gravitational force calculated was between the two 15.0 kg masses rather than between the 15.0 kg and 1.0 kg masses. There is an attempt to link the significance of the calculations to Coulomb's measurements.

The communication is not clear, but it is appropriate at times. The reader must assume that all exponents are to the power of ten, that the units are for the values substituted into the formula, and that the distance between the spheres is 1.0 metre. Significant digits are not handled correctly and no information appears on the diagram. Explanations are logical at times, although they do not reflect a thorough understanding of the physics required. Scientific vocabulary used is somewhat appropriate.

Sample Answer Four (Below Standard, Score 1)

The response addresses some of the major points of the question. The sample calculation uses the correct formula incorrectly. Instead of calculating the two forces and then making a comparison, the student equated the forces to each other to solve for k in order to **compare** the k value with Coulomb's constant k. Visually the response appears organized, however, concepts identified are used inappropriately. For example, the statements explaining that values of k and electrical and gravitational forces are not greatly influenced by gravity makes little or no sense. In addition, the mention of the effects of centripetal and magnetic forces do not address the question being asked. The explanations, therefore, lack consistency of thought. The mathematics, although correct, provide evidence of an attempt to answer the response, but there is a lack of understanding of the physics involved.

The communication rambles through the response. It is not clear how the calculations support the statement that electrical forces are not affected by gravity nor is it clear why the difference between the calculated k value and Coulomb's constant is relevant to the question being answered. Significant digits are not handled correctly, scientific vocabulary is not used appropriately, and no information appears on the diagram.

$m_s = 1.0\text{ kg} \quad m_1 = 15.0\text{ kg} \quad q = 2.6 \times 10^{-8}\text{ c each} \quad F_g = F_e$

$\text{small} = \dfrac{Gm_1m_2}{R^2} = \dfrac{kq_1q_2}{R^2} \qquad \text{large} = \dfrac{Gm_1m_2}{R^2} \qquad Gm_1m_2 = kq_1q_2$

$$(6.67 \times 10^{-11})(1.0)2(15.0)(2) = k(2.6 \times 10^{-8})(2.6 \times 10^{-8})$$

$$k = 5.92 \times 10^{6}\ \text{N•m}^2/\text{C}^2$$

Based on the above calculation, Coulomb's measurements of electrical forces were not significantly affected by the attraction of the spheres' masses due to gravity, because of the difference in the k value—Coulomb's constant.

$$k = 8.99 \times 10^{9}\ \text{N•m}^2/\text{C}^2 - 5.92 \times 10^{6}$$

$$\Delta k = 8.98 \times 10^{9}\ \text{N•m}^2/\text{C}^2$$

These values and the electrical and gravitational forces are not greatly influenced by the force of gravity. However, the centripetal force and the magnetic field force (if applicable) would also affect the value of k, thereby influencing the force due to gravity.

Appendix A Calculator Policy

POLICY: USE OF CALCULATORS ON ALBERTA EDUCATION DIPLOMA EXAMINATIONS

Background

The knowledge, skills, and attitudes relevant to technology and its uses are being incorporated into courses and programs of study wherever appropriate. Students are expected to learn the advantages and limitations of technological developments and their impact upon society. The ability to use technology helps students understand and appreciate the process of technological change, gives added depth to programs, and provides the basis for the development of skills and understanding. These expectations are reflected in the diploma examinations. Since the data provided for writing diploma examinations in mathematics and the sciences do not include information such as logarithms and trigonometric functions, students will need to use scientific calculators for these exams.

Definition

This policy considers a scientific calculator to be a hand-held device designed primarily for mathematical computations. Included in this definition are those scientific calculators having graphing capabilities, built-in formulas, mathematical functions, or other programmable features.

Policy

To ensure compatibility with provincial *Programs of Study* and equity and fairness for all students, Alberta Education expects students to use scientific calculators, as defined above, when they are writing diploma examinations in mathematics and the sciences. Examinations are constructed to ensure that the use of particular models of calculators neither advantages nor disadvantages individual students.

Procedures

1. Teachers must, at the beginning of a course, advise students of the types of calculators that they may use when writing diploma examinations in mathematics and the sciences. Teachers must also advise students of the types of information that can be stored in calculators that are brought into diploma examinations.

2. Students must clear calculators that are brought into diploma examinations of all information previously stored except for
    a. programs used for computing values of the formulas that are provided on the diploma examination tear-out pages or in a separate data booklet for the subject being written,
    b. programs used for Quadratic Relations as found in the Mathematics 30/33 Interim Teacher Resource Manual.

3. Students must not bring external devices to support calculators into the exam. Such devices include manuals, printed or electronic cards, printers, memory expansion chips or cards, external keyboards, or any annotations outlining operational procedures for scientific calculators.

4. In preparation for calculator failure, students may bring extra calculators and batteries into the exam room.

5. During exams, supervising teachers must ensure that
    a. all calculators operate in silent mode,
    b. students do not share calculators or information contained within them,
    c. calculator cases are stored on the floor throughout the exam, and
    d. all examination rules are followed.

6. If you have any questions or comments about the implementation of this policy, please contact the Math/Science Unit, Student Evaluation Branch, at 403-427-0010 or FAX 403-422-4200.

Revised 19 September 94

Appendix B

Examination Rules

GRADE 12 DIPLOMA EXAMINATIONS

1. **Admittance to the Examination Room**
   Students must not enter or leave the examination room without the consent of the supervising teacher.
2. **Student Identification**
   Students must present identification that includes their signature and photograph. One of the following documents is acceptable: driver's licence, passport, or student identification card. Students must not write an examination under a false identity or knowingly provide false information on an application form.
3. **Identification on Examinations**
   Students must not write their names or the name of their school anywhere in or on the examination booklet other than on the back cover.
4. **Time**
   Students must write an examination during the specified time and may not hand in a paper until at least one hour of the examination time has elapsed. Students who arrive more than one hour after an examination has started will not be allowed to write the examination. Students who arrive late but within the first hour of an examination sitting may be allowed to write only at the discretion of the supervising teacher.
5. **Discussion**
   Students must not discuss the examination with the supervising teacher unless the examination booklet is incomplete or illegible. Students must not talk, whisper, or exchange signs with one another.
6. **Answer Sheets**
   Students must use an HB pencil to record their answers on the machine-scorable answer sheets.
7. **Written Responses**
   All work for the written-response sections of the diploma examinations must be done in the examination booklet. Students are expected to write their revised work in blue or black ink for English 30, English 33, Français 30, and Social Studies 30.
8. **Material Exchanges**
   Students must not copy from other students or exchange material. Notes in any form—including those on papers, in books, or stored in electronic devices—must not be brought into the examination room. Calculator programs designed to perform mathematical computations or those designed to assist students in graphing are not classified as notes (see *Calculator Policy*).
9. **Materials Allowed**
   English 30, English 33: Students may use a dictionary and a thesaurus for Part A only. Electronic devices are not allowed for either part.
   Français 30: Students may use a dictionary, a thesaurus, and a book of verb forms for Partie A only. Electronic devices are not allowed for either part.
   Social Studies 30: Students may not use electronic devices.
   Biology 30, Mathematics 30, Physics 30: Tear-out data pages are provided in the examination booklet. Students need to use scientific calculators (see *Calculator Policy*) but must not share them.
   Chemistry 30, Science 30 (Pilot): A separate data booklet is provided for each of these examinations. Students need to use scientific calculators (see *Calculator Policy*) but must not share them.

   Students are expected to provide their own writing materials, including pens and HB pencils, calculators, or other necessary instruments. Tear-out pages for rough work are provided in each biology, chemistry, mathematics, physics and science (pilot) examination booklet.
10. **Translation Dictionaries**
    Students are not allowed to use translation dictionaries in any subject. Exchange students must satisfy the same requirements as other students.

Revised 19 September 199

Appendix C

Guidelines for Significant Digits, Manipulation of Data, and Rounding in the Mathematics and Sciences Diploma Examinations

Significant Digits

1. For all non-logarithmic values, regardless of decimal position, any of the digits 1 to 9 is a significant digit; 0 may be significant. For example:

   123 0.123 0.00230 2.30×10^3
   all have 3 significant digits

2. Leading zeros are not significant. For example:

   0.12 and 0.012 each have two significant digits

3. Trailing zeros to the right of the decimal are significant. For example:

   0.123 00 and 20.000 each have five significant digits

4. Zeros to the right of a whole number are considered to be ambiguous. **The Student Evaluation Branch considers all trailing zeros to be significant**. For example:

   200 has three significant digits

5. For logarithmic values, such as pH, any digit to the left of the decimal is **not** significant. For example:

   a pH of 1.23 has two significant digits
   a pH of 7 has no significant digits

Manipulation of Data

1. When adding or subtracting measured quantities, the calculated answer should be rounded to the same degree of precision as that of the least precise number used in the computation **if this is the only operation**. For example:

   $$\begin{array}{r l} 12.3 & \text{(least precise)} \\ 0.12 & \\ \underline{12.34} & \\ 24.76 & \end{array}$$

   The answer should be rounded to 24.8.

2. When multiplying or dividing measured quantities, the calculated answer should be rounded to the same number of significant digits as are contained in the quantity with the fewest number of significant digits **if this is the only operation**. For example:

   $(1.23)(54.321) = 66.81483$

   The answer should be rounded to 66.8.

3. When a series of calculations is performed, each interim value should not be rounded before carrying out the next calculation. The final answer should then be rounded to the same number of significant digits as are contained in the quantity with the fewest number of significant digits. For example:

   In determining the value of $(1.23)(4.321)/(3.45 - 3.21)$, three calculations are required:

   a. $3.45 - 3.21 = 0.24$

   b. $(1.23)(4.321) = 5.31483$

   c. $5.31483/0.24 = 22.145125$

   [Not $5.31/0.24 = 22.125$]

   The value should be rounded to 22.1.

Rounding

1. When the first digit to be dropped is less than or equal to 4, the last digit retained should not be changed. For example:

   1.2345 rounded to three digits is 1.23

2. When the first digit to be dropped is greater than or equal to 5, the last digit retained should be increased by one. For example:

   12.25 rounded to three digits is 12.3

Appendix D

Explanations of Cognitive Levels

Knowledge refers to those behaviours and test situations that emphasize the remembrance, either by recognition or recall, of ideas, material, or phenomena.

Comprehension refers to responses that demonstrate an understanding of the literal message contained in a communication.

Application requires the student to apply an appropriate abstraction (theory, principle, idea, method) to a new situation.

Analysis comprises the ability to recognize unstated assumptions, to distinguish facts from hypothesis, to distinguish a conclusion from statements that support it, to recognize facts or assumptions that are essential to a main thesis, to distinguish cause-effect relationships from other sequential relationships, and to recognize a writer's viewpoint.

Synthesis is the production of a unique communication. It is the ability to propose ways of testing hypotheses, the ability to design an experiment, the ability to formulate and modify hypotheses, and the ability to make generalizations.

Evaluation is defined as making judgements about the value of ideas, solutions, and methods. It involves the use of criteria to appraise the extent to which details are accurate, effective, economical, or satisfying. Evaluation includes the ability to apply given criteria to judgements of work done, to indicate logical fallacies in arguments, and to compare major theories and generalizations.

Directing Words

Discuss
The word "discuss" will not be used as a directing word on math and science diploma examinations because it is not used consistently to mean a single activity.

The following words are specific in meaning The corresponding cognitive levels are enclosed in parentheses.

Contrast/Distinguish
Point out the *differences* between two things that have similar or comparable natures. (Analysis)

Compare
Show the character or relative values of two things by pointing out their *similarities* and *differences*. (Analysis and/or Evaluation)

Conclude
State a logical end based on reasoning and/or evidence. (Evaluation)

Criticize
Point out the *merits* and *demerits* of an item o issue. (Analysis and Evaluation)

Define
Provide the essential qualities or meaning of a word or concept. Make distinct and clear by marking out the limits. (Knowledge)

Describe
Give a written account of or represent the characteristics by a figure, model, or picture. (Knowledge)

Design/Plan
Construct a plan, i.e., a detailed sequence of actions, for a specific purpose. (Application and/or Synthesis)

Enumerate
Specify one by one or list in concise form and according to some order. (Knowledge)

Evaluate
Give the significance or worth of something by identifying the good and bad points or the advantages and disadvantages. (Analysis and Evaluation)

Explain
Make clear what is not immediately obvious or entirely known; give the cause of or reason for; make known in detail. (Comprehension)

How
Show in what manner or way, with what meaning. (Comprehension)

Hypothesize
Form a tentative proposition intended as a possible explanation for an observed phenomenon; i.e., a possible cause for a specific effect. The proposition should be testable logically and/or empirically. (Analysis and Synthesis)

Identify
Recognize and select as having characteristics of. (Knowledge)

Illustrate
Make clear by giving an example. The form of the example must be specified in the question; i.e., word description, sketch, or diagram. (Comprehension and/or Application)

Infer
Form a generalization from sample data; arrive at a conclusion by reasoning from evidence. (Evaluation)

Interpret
Tell the meaning of; present information in a new form that adds meaning to the original data. (Comprehension)

Justify/Show How
Show reasons for or give facts that support a position. (Evaluation)

Outline
Give, in an organized fashion, the essential parts of. The form of the outline must be specified in the question; i.e., lists, flow charts, concept maps. (Knowledge and/or Comprehension)

Predict
Tell in advance on the basis of empirical evidence and/or logic. (Application)

Prove
Establish the truth, validity, or genuineness of something by giving factual evidence or logical reasons. (Evaluation)

Relate
Show logical or causal connection between. (Analysis)

Solve
Give a solution for a problem, i.e., explanation in words and/or numbers. (Analysis and Synthesis)

Summarize
Give a brief account of the main points. (Comprehension)

Trace
Give a step-by-step description of the development. (Knowledge)

Why
Show the cause, reason, or purpose. (Comprehension and/or Synthesis)

Appendix E

Preparing to Write a Science Diploma Examination—What every student should do before the examinations!

1. Prepare a course review schedule:
   - design your schedule for the two-week period (minimum) before the examination
   - divide the course material into sections and indicate on the schedule the time blocks to be devoted to each section
     - take into account the examination blueprint available from your teacher (*Diploma Examinations Program Information Bulletin* for the course). Note that course units are not equally weighted on the diploma examination
     - take into account units/concepts that you find most difficult; i.e., allocate more time for the review of these

2. Obtain and review examination schedules, rules, and policies:
   - record the time and place of writing
   - note minimum and maximum writing times permitted
   - prepare to remain in the examination room for at least 2.5 h (Kleenex, cough drops, etc.)
   - identify materials allowed for writing each examination, such as pencils, pens, calculators, mathematical instruments, and clear plastic ruler

3. Identify and collect examples of each type of question that will be asked:
   - obtain a copy of the relevant information contained in the *Diploma Examinations Program Information Bulletin* for the course (available from your teacher)
   - review the format of previous diploma examinations (available from your teacher)
   - learn the meanings of key "directing" words such as compare, describe, evaluate, explain, illustrate, interpret, justify, prove, and solve

4. Make summaries and point form outlines:
   - distinguish between major concepts and factual details
   - identify essential skills that can be assessed on paper and pencil tests
   - review lab results and procedures—identify connections between lab reports class notes, and textbook
   - anticipate examples of connections between concepts and the "real world"
   - prepare a glossary of important subject terminology
   - review the data booklet for Chemistry 30 or Physics 30, and review formulas and equations if applicable
   - link each formula or equation with a calculation done on a previous test or assignment
   - identify any restriction on the use of each formula or equation

5. Use memory aids such as:
   - colour coding, underlining, highlighting, jotting keywords in margins
   - numbering points to be memorized
   - grouping word and idea associations
   - reading aloud key words, expressing key words in your own words

6. Review the different question formats and the instructions on how to answer these questions.

Appendix F

Suggestions for Students When Writing Science Diploma Examinations—What every student should know when writing examinations!

1. Do not be afraid to answer each question even if you are not sure of the correct solution to the problem. A penalty is NOT given for guessing on the machine-scored section the exam. Partial marks are often awarded for incomplete answers in the written-response section of the exam.

2. If you are stuck on a question, mark the alternatives that you know are incorrect and choose from the ones that are left using logical guessing strategy. Think of the questions as challenges and cultivate a positive attitude about your ability to answer them.

3. Scan the sets of questions of the examination before answering a particular question. The questions in one set of the examination may jog your memory about a question in another set.

4. When first reading a multiple-choice question, locate and circle key words to help clarify the meaning of the question. Then hide the alternatives and try to formulate an answer of your own. Your answer may be very close to the correct alternative.

5. If a multiple-choice question involves a calculation, do the calculation and select the alternative that is closest to your answer. A multiple-choice calculation is usually short. If you cannot do it in five minutes, your method is either inappropriate or incorrect. Go on.

6. Diagrams on examinations are often labelled with numbers or letters. It may be useful to write in the names of the labelled structures or features that you can identify.

7. When reading graphs, use a clear plastic ruler to more accurately extrapolate or interpolate data.

8. Have a good reason for changing an answer. Do not change an answer on a hunch. Do not waste your time looking for patterns of As, Bs, Cs, or Ds in multiple-choice answers. There are none.

9. You may not have time to write and edit a complete rough copy for each written-response question, but you should prepare an outline of your answer and use it as a guide when writing your good copy.

10. When completing a written-response question, keep in mind the reader of your response. The reader will want to know how well you:
    - understand the problem or the mathematical/science concept
    - can correctly use the mathematics involved
    - can use problem-solving strategies and explain your answer and procedures
    - can communicate your solutions and mathematical/science ideas

11. Rewriting a statement of the question is often a good way to begin a written response. Conclude with a summary statement. Be sure you have clearly explained all assumptions and have verified your conclusions.

12. Keep track of the time and pace yourself. Put a check mark by items that you are uncertain about and return to them if there is time at the end of the examination.

DATE DUE SLIP

F255	○

sics 30 Information Bulletin Physics 30 Information Bulletin Physics 30 Information Bulletin Ph
on Bulletin Physics 30 Information Bulletin Physics 30 Information Bulletin Physics 30 Informati
sics 30 Information Bulletin Physics 30 Information Bulletin Physics 30 Information Bulletin Ph
on Bulletin Physics 30 Information Bulletin Physics 30 Information Bulletin Physics 30 Informati
sics 30 Information Bulletin Physics 30 Information Bulletin Physics 30 Information Bulletin Ph
on Bulletin Physics 30 Information Bulletin Physics 30 Information Bulletin Physics 30 Informati
sics 30 Information Bulletin Physics 30 Information Bulletin Physics 30 Information Bulletin Ph

MAY 02 1995

University of Alberta Library

0 1620 0282 5295